Journal of Electrical, Control and Telecommunication Research 1 (2020) 23 – 29

Journal of
Electrical, Control and Telecommunication Research

Journal homepage: www.sciengtexopen.org/index.php/jectr

# Analysis of energy revenue and electrical power losses in distribution line

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ARTICLE INFO

*Article history:*
Received 4 November 2019
Received 15 January 2020
Accepted 28 February 2020
Published 1 April 2020

*Keywords:*
Billing
Cash amount
Energy losses
Power distribution system

ABSTRACT

This study presents the analysis of energy revenue and electrical power losses in distribution network, aimed to determine the energy losses on power distribution system. The 11kV power transmission line at Ujokuen community feeding to Benson Idahosa University was investigated. The following data were obtained as follow: energy delivered, energy billing, total cash amount, billed collected and correspond percentage. From the research work various technical power losses associated with power distribution network were determined and their effect on energy delivered and energy billing and corresponding difference under the area of investigation. It was observed that energy delivered is not constant or linear for the year 2013. The comparison of energy delivered and energy billed for various years were determined. It was observed that there is decreased in energy delivered and energy billed from 2013 to 2015 and the system witnessed a slightly increase of energy delivered and energy billed from 2016 to 2018. The energy level differentials are due to copper losses, energy theft and core loss.

https://doi.org/10.37121/jectr.vol1.114

## 1. Introduction

Growing population and industrialization create huge need for electrical energy [1], [2]. Unfortunately electricity is not always used in large demand in the same location it is been generated. Hence, long cables and conductors are used to transmit the generated electrical power through overhead and underground system known as transmission. Transmission as good as it may sound, i.e., making electrical power available to all consumers at different locations and distances far away from generating stations has its own short comings or challenges, of which losses is a major one [3]. Distribution line losses refer to the difference amount of energy delivered to the distribution system and the amount energy consumers are billed. It is important to know the magnitude and cause factors of line losses because the cost is recovered from consumers. The difference between the transmission and distribution (T&D)

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energy units is referred to as transmission and distribution losses, which can be expressed as T&D losses equal to the energy input to feeder (kWh), minus billed energy consume (kWh), divided by energy input kWh multiple by one hundred [4], [5].

Basically, there two types of losses associated with transmission and distribution of energy; technical and non-technical (commercial) losses. The losses associated with power transmission were identified in [3] and introduced method of capacitor bank to reactive power at the receiving of a system, which is known as VAR compensator, appropriate sizing and placement of capacitors to a system in order to reduce power loss and enhance the voltage profile was considered by [4]. The study further stressed that the optimal allocation of capacitor banks and distributed generation (DG) units are some of the tasks in power network planning. [6], [7]. Naij et al. [5] presented an approach to reduce energy losses in an electric power network. In order to develop the strategy, a model was constructed to simulate an electrical distribution network, and different parameters were included that help in estimation of technical losses in medium voltage distribution network. However, the non-technical losses cannot be estimated or computed beforehand [8], [9]. Majority of these losses are probably caused by electricity theft; although, there are other possibilities such as poor maintenance, accounting flaws, and perhaps, some power networks may suffer from these setbacks [10], [11].

This study aims to determine the energy losses and the impact on energy revenue on power distribution system in Nigeria as well as to profane possible solution to reduce energy losses experience in power distribution networks.

## 2. Methodology

In this study, a survey was carried out on the evaluation of energy revenue and electrical power losses in distribution line at Benson Idahosa University (BIU) at Benin City. The data obtained were Energy Delivered, Energy Bill, Percentage of Energy Bill from Energy delivered. In addition, total amount billed, cash collected, percentage of cash collected from total amount billed, 11kV line to Ujokuen Community which is fed in the BIU. Factors such has time, energy delivered, energy billed, total amount billed etc. were considered.

### *2.1. Electricity Usage Estimation*

To estimate electricity usage of a particular appliance or electronic device, need three factors (wattage of the appliance, average number of hours use it per day and price paid per kilowatt-hour (kWh) of electricity). The kWh rate was obtained from the customer's electricity bill, and the average daily usage deduced. The wattage of an appliance can be determined from the label or metal plate, placed at the back or bottom of the appliance. Alternatively, it can be determined from the appliance's manual. The cost of electricity is determined with this formula:

$$COE = W \times h \times r / 1000 \tag{1}$$

Where W is the device's wattage, h is the hours of appliance usage and r is the kWh rate. The summary of energy data collected from 11kV transmission line feeding Benson Idahosa University and environ at Ujokuen community are energy delivered, energy billed and the differences between the energy delivered and energy billed for each year from 2013 to 2018 are presented in table 1.from the table 1, the total energy delivered, energy billed and the difference in the energy were determine.

The analysis of energy data collected from 11kV transmission line feeding Benson Idahosa University and environ at Ujokuen community for period of six years from January 2013 to December 2018 are presented in Table 1.

**Table 1.** Analysis of energy delivered and cash collected 11kV transmission line feeding BIU

| Years | Energy delivered | Energy billed | Energy difference | Amount billed | Cash collected |
|---|---|---|---|---|---|
| 2013 | 246402151 | 202757415 | 43644736 | 39000919815.11 | 20861525726.12 |
| 2014 | 242347206 | 181823481 | 60523725 | 40781783327.50 | 23612090921.23 |
| 2015 | 201495474 | 131568899 | 69926575 | 38996895219.18 | 25949295358.23 |
| 2016 | 175403578 | 149,687229 | 25716349 | 51384737071.40 | 26990219689.42 |
| 2017 | 181003385 | 150347723 | 30655662 | 62893515576.83 | 35482617177.56 |
| 2018 | 206841818 | 176979382 | 29862436 | 75388803208.05 | 41810987255.88 |
| Average | | | | 51407775703 | 29117789355 |

### *2.2. Differential Power Loss Technique*

Power loss can be stated as the difference between the transmitted power and received power as expressed in Fig. 1, using the relation between the power sent, power received and associated losses in the power system. The efficiency ($\eta$) of transmission is given as:

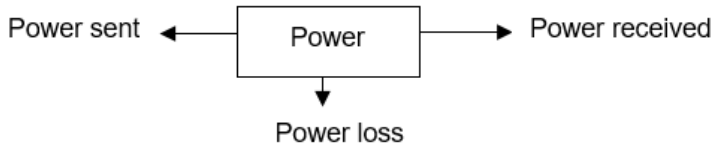


**Fig. 1** Relationship between sent and received power

$$\eta = P_{out} / P_{rec} \tag{2}$$

$$\eta = 1 - \frac{2I^2R}{VI} \tag{3}$$

$$\eta = \frac{1 - P_{loss}}{P_{sent} + P_{loss}} = \frac{P_{sent}}{P_{sent} + P_{loss}} \tag{4}$$

Where $P_{out}$ is the power output, $P_{rec}$ is the power received, $P_{loss}$ is the power loss and $P_{sent}$ is the power sent.

## 3. Results and Discussion

Figs. 2 to 5 shows the analyses of results obtained. In Fig 2, the energy delivered against the year was considered. It was observed that energy delivered is not constant or linear for the year 2013Therefore, the availability of power is not constant resulting from the fluctuation in the amount of energy delivered throughout the year 2013. These energy level differentials are due to copper losses, energy theft and core losses etc.

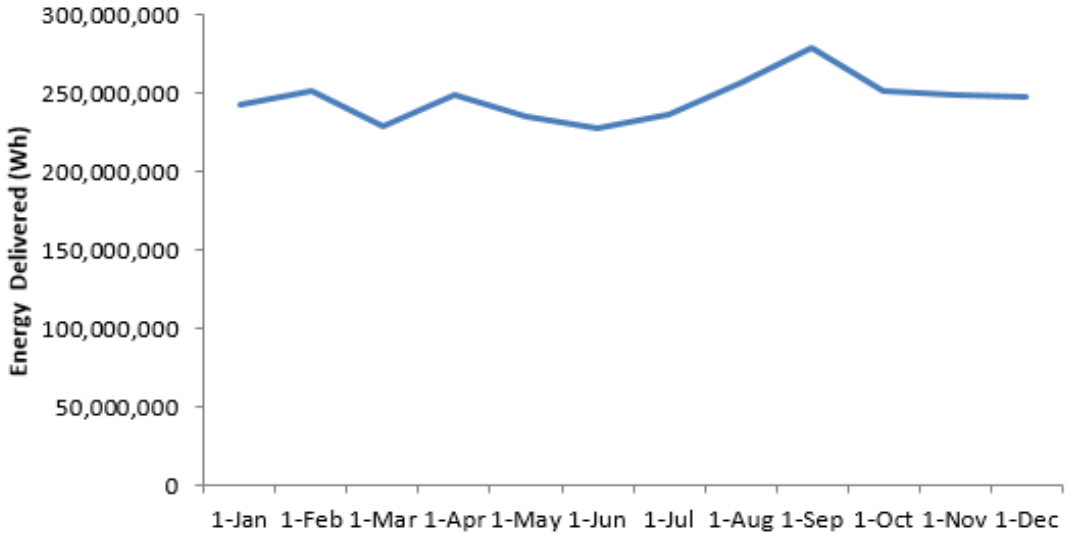


**Fig. 2** Profile of energy delivered for year 2013

Fig. 3 shows the comparison between energy delivered and energy bill for year 2013. It was observed from the bar chart that both delivered energy and energy billed in 2013 are not the same; therefore losses availability in power network was established. Such could be copper, core loss etc. These energy losses are established due to the variation between delivered energy and energy billed. A corresponding comparison of energy delivered and energy billed for various years is presented in Fig 4.

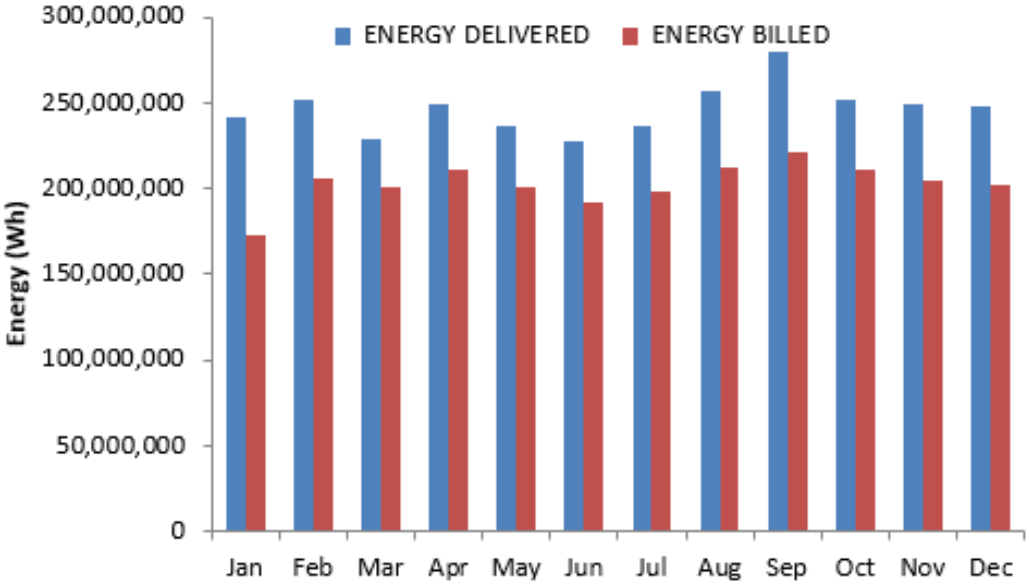


**Fig. 3** Comparison of energy bill and energy delivered for year 2013

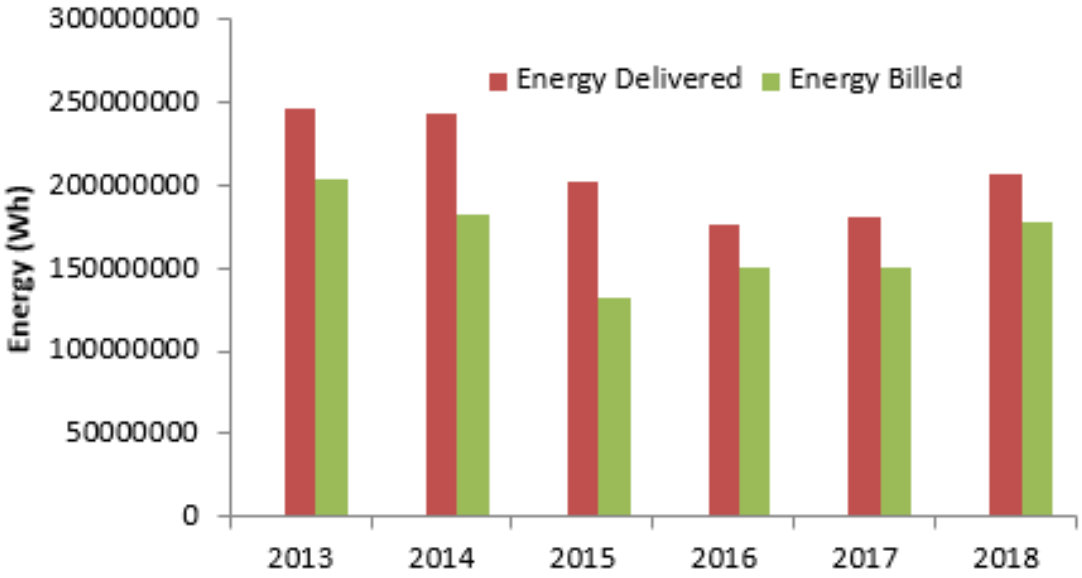


**Fig. 4** Comparison of energy bill and energy delivered various years

It was observed (Fig. 4) that there is decreased in Energy Delivered and Energy billed from 2013 to 2015 and the system witnessed a slightly increase of Energy Delivered and Energy billed from 2016 to 2018. The differences in energy level for various years are presented in Fig 5. The energy level differentials are due to copper losses, energy theft and core loss etc.

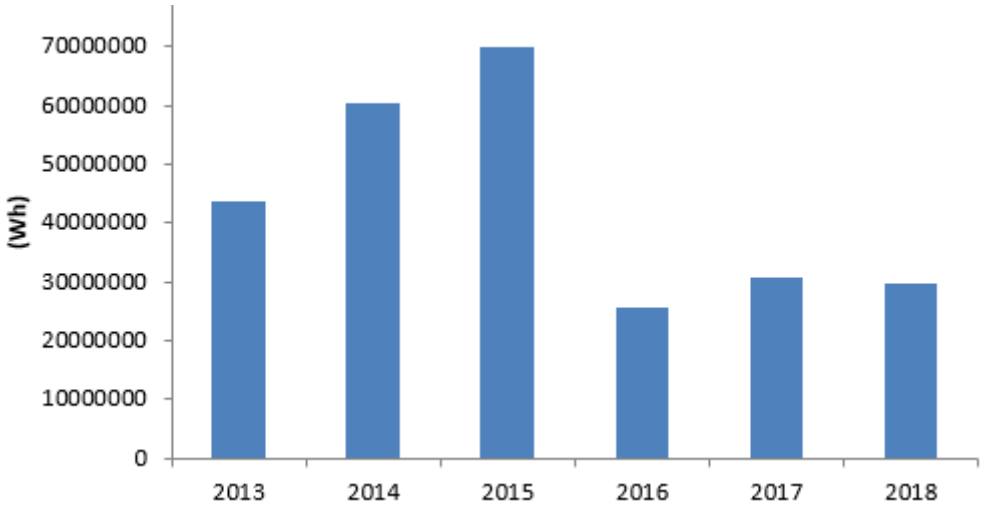


**Fig. 5** Difference in energy level for various years

Fig. 6 and Fig. 7 show comparisons between total amount billed and cash collected.

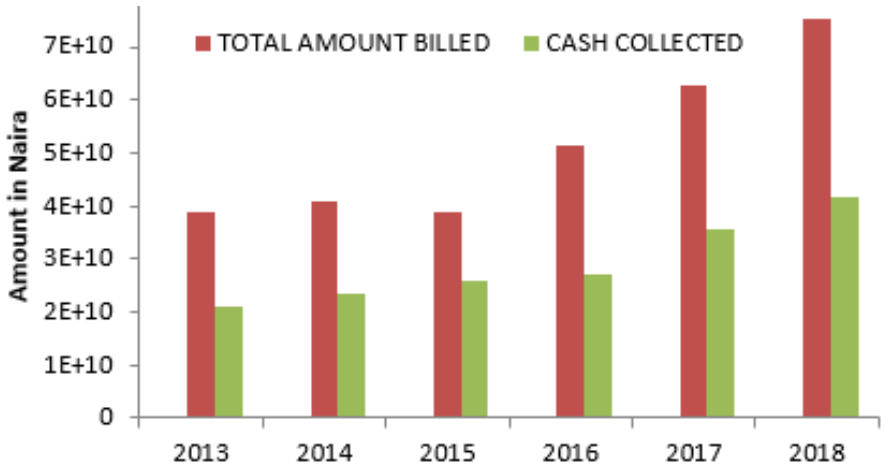


**Fig. 6** Comparison of annual total bill and cash collected

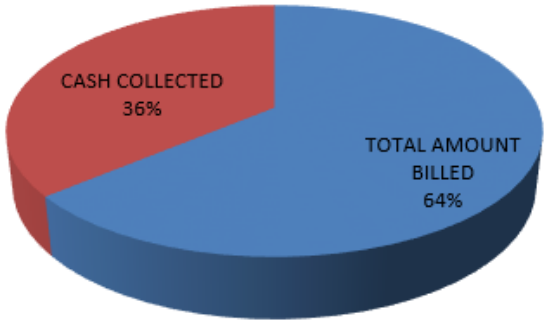


**Fig. 7** Percentage comparison of total amount billed and cash collected

The technical losses present in power distribution network also result to losses of energy in terms of revenue collection. However, deployment of silver conductor and reduction in core losses using silver conductor can help to reduces losses. In addition, using the correct cable sizing rate, avoiding joints along the cable lines, excessive long span cable can lead losses of energy, unmetered load customers and lastly elimination of energy theft. All these factors can reduce energy losses and also affects over all energy revenue collection in that region.

## 4. Conclusion

Technical power losses associated with power distribution network were determined and their effect on energy delivered and energy billing and corresponding difference under area investigated. It was observed that energy delivered is not constant or linear for the year 2013. Therefore, the availability of power is not constant. The comparison of energy delivered and energy billed various years. It was observed that there is decreased in energy delivered and energy billed from 2013 to 2015 and the system witnessed a slightly increase of energy delivered and energy billed from 2016 to 2018. The energy level differentials are due to copper losses, energy theft and core loss.

## Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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**Citation**: O. A. Osahenvemwen, S. E. Ogunbor, and J. E. Okhaifoh “Analysis of energy revenue and electrical power losses in distribution line,” *Journal of Electrical, Control & Telecommunication Research,* vol. 1, pp. 23 – 29, 2020.